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ST. LOUIS AIR POLLUTANT EMISSION
INVENTORY

Michael McGraw, et al

National Air Pollution Control Administration
Durham, North Carolina

August 1968

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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16. Abstracts The objectives were to determine the total quantities of the various air pollutants emitted and to estimate the geographical variation in their emissions. The study area was divided into a grid coordinate system, and the emissions were reported in terms of tons of pollutant per grid on average annual day, average summer day, and average winter day. The pollutants considered were sulfur oxides, particulates, carbon monoxide, hydrocarbons, and oxides of nitrogen. The data should be representative, for the most part of 1967. The study area consisted of the City of St. Louis and seven surrounding counties; it occupies 4,499 square miles and contains an estimated 1967 population of 2,412,000. More than 95 percent of the population and almost all of the industrial activity are located in the 400 square miles of the centrally located urbanized part. The emissions can be almost entirely attributed to this urbanized portion. For each pollutant, a summary of the emissions is tabulated for these source categories: transportation (road vehicles, other); combustion of fuels from stationary sources (industry, steam-electric, residential, other); refuse disposal (incineration, open burning); and industrial process emissions.																							
17. Key Words and Document Analysis. 17a. Descriptors <table border="0"> <tr> <td>Air pollution</td> <td>Nitrogen oxides</td> </tr> <tr> <td>Exhaust emissions</td> <td>Transportation</td> </tr> <tr> <td>Inventories</td> <td>Ground vehicles</td> </tr> <tr> <td>Urban areas</td> <td>Fuels</td> </tr> <tr> <td>Seasonal variations</td> <td>Industrial wastes</td> </tr> <tr> <td>Sulfur oxides</td> <td>Steam electric power generation</td> </tr> <tr> <td>Particles</td> <td>Residential areas</td> </tr> <tr> <td>Carbon monoxide</td> <td>Solid waste disposal</td> </tr> <tr> <td>Hydrocarbons</td> <td>Incinerators</td> </tr> <tr> <td></td> <td>Open burning</td> </tr> </table>				Air pollution	Nitrogen oxides	Exhaust emissions	Transportation	Inventories	Ground vehicles	Urban areas	Fuels	Seasonal variations	Industrial wastes	Sulfur oxides	Steam electric power generation	Particles	Residential areas	Carbon monoxide	Solid waste disposal	Hydrocarbons	Incinerators		Open burning
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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
U. S. Public Health Service
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Air Quality and Emission Data Program
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3. Missouri Air Conservation Commission.

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AIR POLLUTANT EMISSION INVENTORY

INTRODUCTION

This report presents the results of an emission inventory of air pollutant sources in the St. Louis metropolitan area, based primarily on the rapid survey technique¹. The objectives of this study were to determine the total quantities of the various air pollutants emitted and to estimate the geographical variation in air pollutant emissions. To accomplish this task, the study area was divided into a grid coordinate system, and the emission quantities were reported in terms of tons of pollutant per grid on average annual day, average summer day, and average winter day.

The pollutants considered in the survey were sulfur oxides, particulates, carbon monoxide, hydrocarbons, and oxides of nitrogen. Data presented herein should be representative, for the most part, of 1967 and were mainly gathered by the acknowledged State and local agencies. The report is essentially an up-dating of the emission inventory which was conducted during 1963-1964 as part of the St. Louis-East St. Louis Interstate Air Pollution Study². All sources of air pollutant emissions were not considered in the survey, e.g. solvent evaporation. However, all other major source categories have been included.

STUDY AREA

The Study Area, as presented in Figure 1A, consists of the City of St. Louis and seven surrounding counties - St. Louis, St. Charles, Franklin, and Jefferson Counties in Missouri and Madison, St. Clair, and Monroe Counties in Illinois. This area occupies 4,499 square miles and contains an estimated 1967 population of 2,412,000 which is a 14 percent increase over 1960 (Table 1)³. More than 95 percent of the population and almost all of the industrial activity are located in the 400 square miles of the centrally located urbanized part (Figure 1B) of the

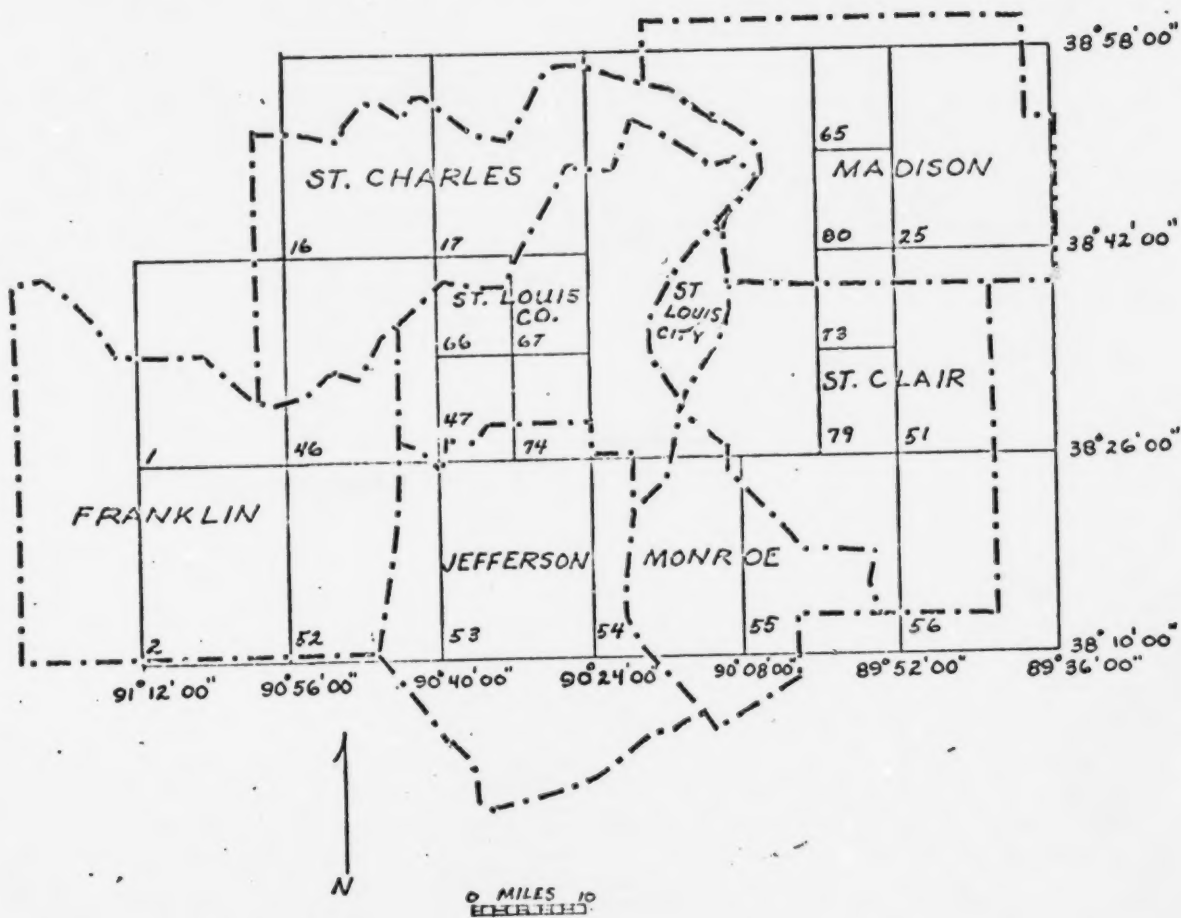


Figure 1A. St. Louis Air Pollutant Study Area

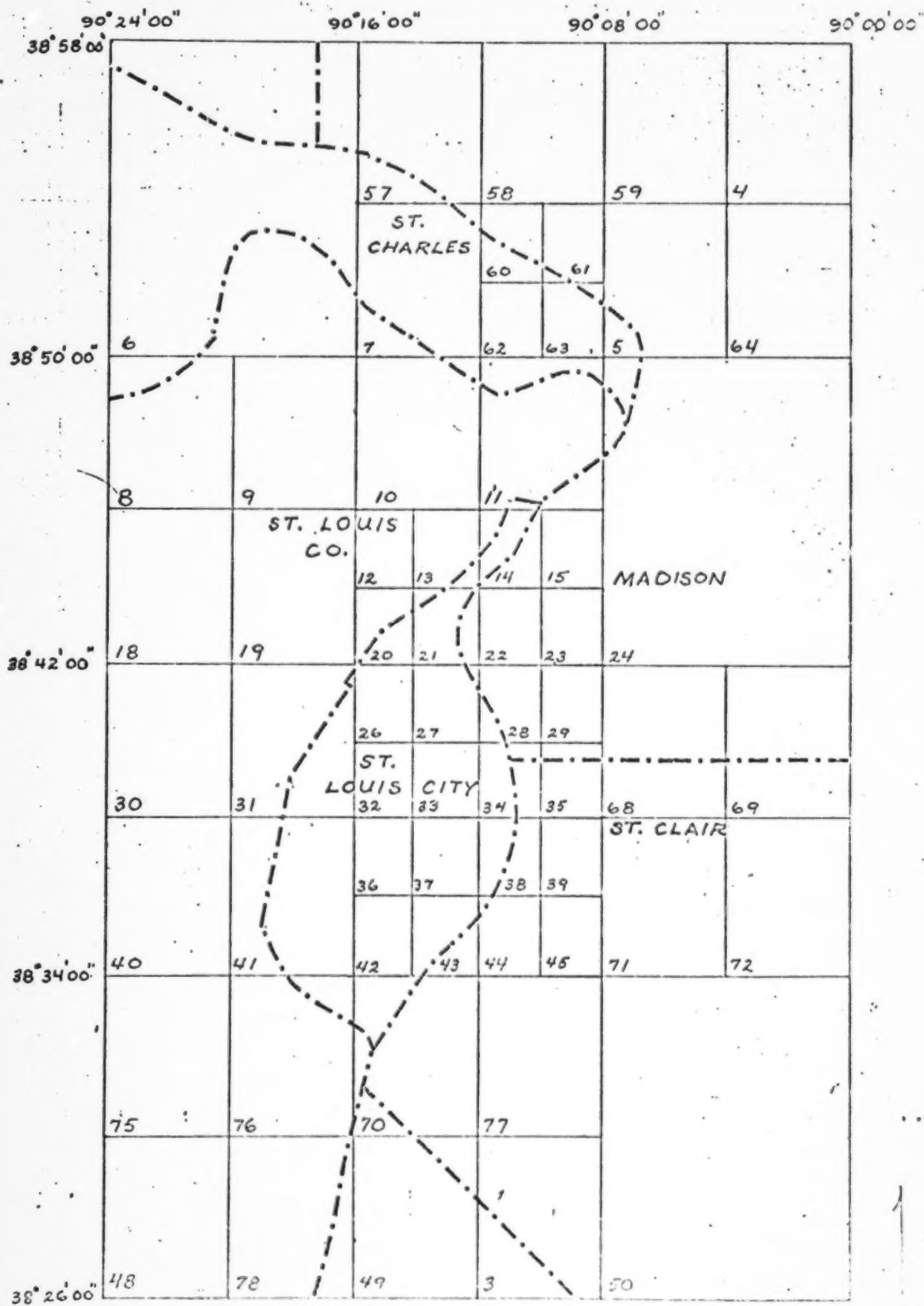


Table 1. POPULATION FIGURES FOR
THE ST. LOUIS STUDY AREA ³

<u>Political Jurisdiction</u>	<u>1960</u>	<u>1967</u>	<u>Percent Increase</u>
St. Louis City	750,026	693,000	- 7.6
St. Louis County	703,532	942,000	+ 33.9
Franklin County	44,566	54,000	+ 21.2
Jefferson County	66,377	95,000	+ 43.1
St. Charles County	52,970	81,000	+ 52.9
Missouri Total	1,617,471	1,865,000	+15.3
Madison County	224,689	251,000	+ 11.7
St. Clair County	262,509	279,000	+ 6.3
Monroe County	15,507	16,900	+ 8.9
Illinois Total	502,705	546,900	+ 8.8
Area Total	2,120,176	2,411,900	+ 13.7

Study Area. The pollutant emission data presented can be almost entirely attributed to this urbanized portion of the area. A land-use map provides an excellent index to the areal distribution of most pollutant emissions and is presented in Figure 2. This particular map was prepared in 1957, but an analysis of the 1967 land use data for St. Louis shows essentially the same features.

Topography

The St. Louis area is gently rolling, generally with gradual undulations rather than sharply defined ridges and valleys. Although there are a few rises and drops of 100 feet in elevation over a short distance, the area within a 25 mile radius of downtown St. Louis is generally free of major orographic features that strongly influence meteorological variables. In general, elevations range from 480 feet above sea level in the downtown St. Louis area to about 550 feet at Lambert Field, 12 miles away, with a slight ridge rising to 600 feet in between. A flat area known as the American Bottoms, surrounded by a crescent-shaped bluff rising to an average of 640 feet above sea level, lies on the east side of the Mississippi River across from St. Louis. The boundary bluff extends from Alton, Illinois, on the north, passes 10 miles east of the Mississippi at East St. Louis, and returns to within 3 miles of the Mississippi opposite the mouth of the River des Peres on the south.

The average elevation of the Mississippi River is 400 feet above sea level, and of the American Bottoms 420 feet above sea level, about 60 feet below the main commercial area of St. Louis. The Springfield and Decatur SMSA's are located approximately 50 miles northeast of the Study Area. There are no other large industrial or populated areas within a radius of 100 miles.

General Climatology

The St. Louis area experiences the meteorological condi-

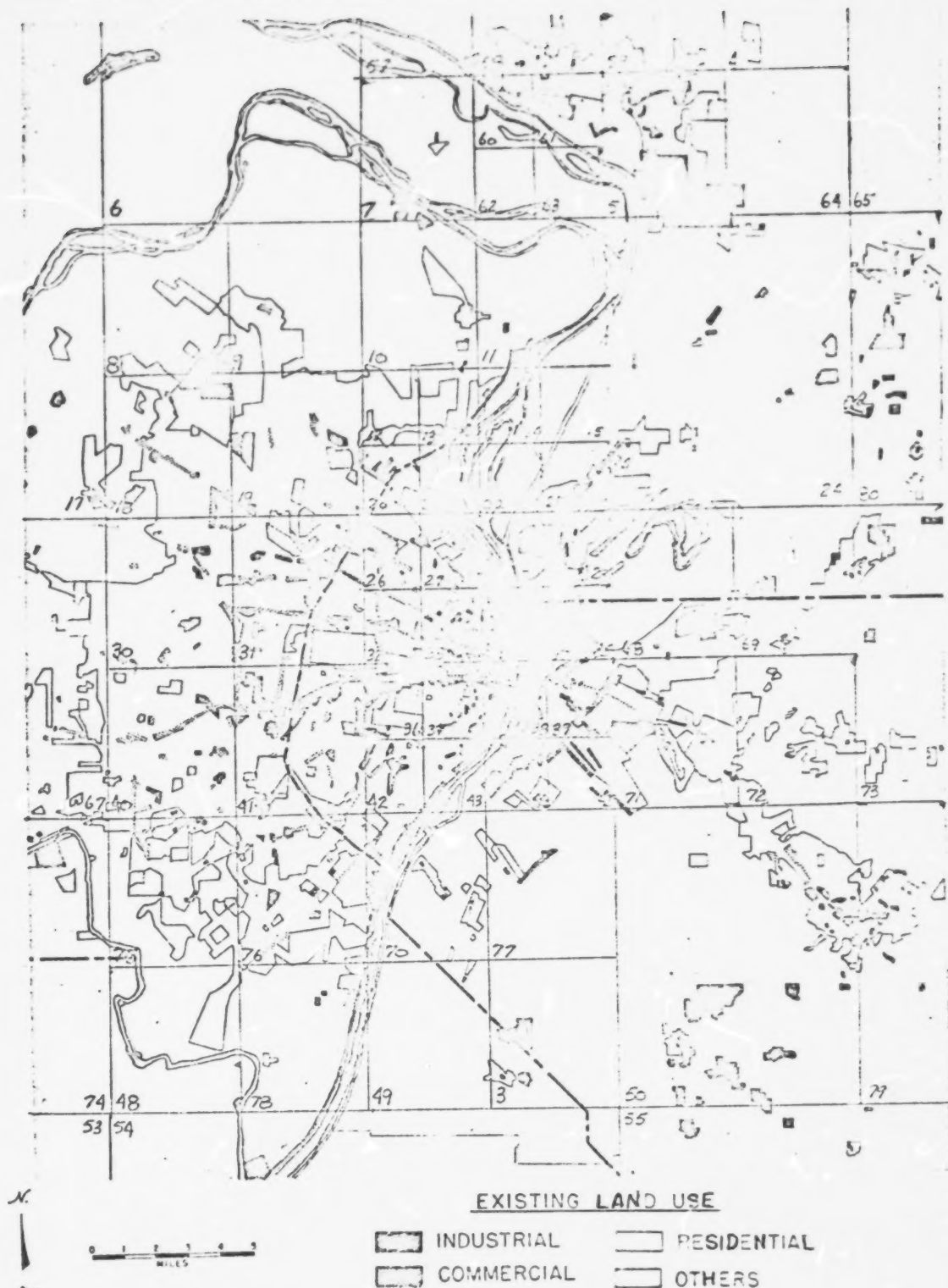


Figure 2. Land use in Metropolitan St. Louis

tions typical of most Great Plains' cities that are not influenced by major natural features such as mountains or large bodies of water. The winters are brisk and as a rule are seldom severe. Almost every winter has several periods of mild weather and occasional short spells of extreme cold. Summers are generally warm, whereas spring and fall are characterized by moderate temperatures.

Marked variations in day-to-day conditions are provided by changes from warm, moist air flowing up from the Gulf of Mexico during some periods, to cool, dry air from the Northern Plains during others.⁴

Grid Coordinate System

For the purposes of this survey, the Study Area was divided into 80 grids based on latitude and longitude. Four grid sizes of 2 minutes, 4 minutes, 8 minutes, and 16 minutes were utilized for delineating emissions of sulfur oxides, particulates, and oxides of nitrogen (Figures 1A and 1B); and one grid size of 15 minutes was used for emissions of carbon monoxide and hydrocarbons (Figure 3). This latter system was utilized because traffic flow and vehicular-mile data were not available on the smaller grid basis.

SUMMARY OF RESULTS

The following is a brief summary of pollutant emissions and sources in the Study Area:

1. Particulate matter (184,900 tons per year) is emitted primarily from the combustion of coal, various industrial processes, and transportation sources. The combustion of coal contributes 66 percent, industrial processes 26 percent, and transportation 5 percent of the total particulate emissions. Other sources contribute the remaining 3 percent.

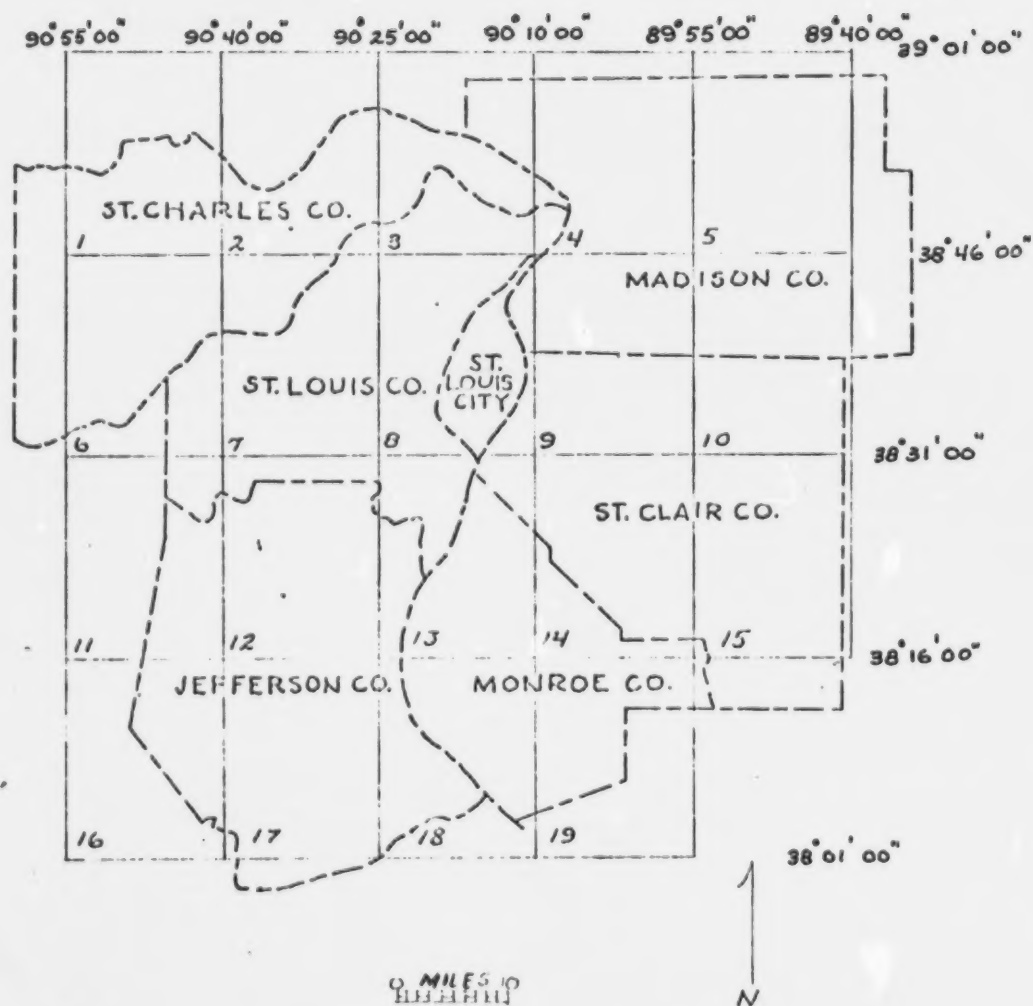


Figure 3. Grid Coordinate System for Emissions of Carbon Monoxide and Hydrocarbons.

2. More than 81 percent of the total sulfur oxide emissions are discharged during the combustion of fossil fuels. The burning of coal contributes more than 78 percent and fuel oil 3 percent of the total emissions. Industrial process emissions account for approximately 18% of the total emissions. Total sulfur oxide emissions were 665,000 tons per year.
3. Oxides of nitrogen (181,000 tons per year) are discharged primarily from the burning of coal (53 percent), transportation sources (31 percent), and burning of natural gas (9 percent). Other sources contribute 7 percent.
4. Motor vehicles emit approximately 84 percent and industrial process emissions almost 13 percent of the total hydrocarbons included in this survey. Total hydrocarbon emissions were 326,400 tons per year (excluding solvent evaporation).
5. The major source of carbon monoxide emissions (1,644,00 tons per year) is the operation of gasoline-powered motor vehicles, which emit 77 percent of the total emissions. Industrial processes contribute 20 percent of the total emissions.

The emissions of pollutants discharged to the air from the Study Area are summarized in Table 2. The validity of the results depends primarily on the accuracy and applicability of the presently available emission factors.⁵ These factors, for the most part, represent the average emission rates for a particular industry or fuel group. Because of the inherent differences in type of equipment, operating rates, and efficiency of operation among the plants or fuel users within a given category, the application of the emission factors to any individual plant or even a smaller number of similar plants or processes may result

Table 2 SUMMARY OF AIR POLLUTANT EMISSIONS IN
THE ST. LOUIS AIR POLLUTION STUDY AREA, 1967 (TONS/YEAR)

Source category	Particulates	Sulfur oxides	Nitrogen oxides	Hydrocarbons	Carbon monoxide
Transportation	8,800	5,100	56,000	276,000	1,271,000
Road vehicles	5,400	4,100	49,900	267,000	1,245,000
Other	3,400	1,000	6,100	9,000	26,000
Combustion of fuels from stationary sources	123,210	542,102	118,982	6,668	28,197
Industry	46,300	113,924	32,530	1,172	3,258
Steam-electric	50,411	368,592	72,386	684	1,402
Residential	22,058	49,201	11,986	4,249	20,744
Other	4,441	10,385	2,080	563	2,793
Refuse disposal	4,918	634	2,163	887	17,561
Incineration	2,294	306	361	68	2,052
Open burning	2,624	328	1,802	819	15,509
Industrial process emissions	48,000	117,781	3,995	42,874	327,600
Totals	184,928	665,617	181,140	326,429	1,644,358

in a considerable discrepancy between the actual and estimated emissions. However, the estimates of total pollutants from all sources in the Study Area should be fairly accurate since the emission factors are based on average conditions.

Some of the estimates presented in this survey are reported to six significant figures, but because of the limitations of the data involved, they should be considered accurate to no more than two significant figures.

Since this inventory is essentially an updating of the 1963 Interstate Air Pollution Study, any large differences in emissions from 1963-67 can be explained either in terms of new or controlled sources.

The increase in emissions from transportation sources is primarily due to the growth in motor vehicle activity in the Study Area. This increase is a natural outgrowth of the increase in population and the increasing popularity of the automobile as a source of transportation.

The increase in particulate and sulfur oxide emissions since 1963 by steam-electric utilities is primarily due to the portage de Sioux power plant, which was not on line in 1963. The coal consumption used for this plant was an estimated capacity, and according to reports the plant did not actually operate at this rated capacity.

The fact that emissions from residential sources increased in 1967 is misleading. A more detailed survey was made in 1967 than in 1963 on coal consumption in the City of St. Louis. This study showed that the amount of coal consumed by residential sources was much higher than that reported for 1963. Since no new homes between 1963 and 1967 burned coal, then the coal value reported for 1963 was actually too low. For this reason emissions from this source are higher than those reported in 1963.

Sulfur Oxide emissions from industrial processes was higher than in 1963 because a lead smelting plant, which emits 84,200 tons annually, was not included in the 1963 survey.

In the Study Area a large number of open-burning dumps were replaced by sanitary land-fills. The emissions from open burning were, therefore, considerably less in this survey than in the 1963 survey.

EMISSIONS BY CATEGORY

For the purposes of compiling the basic data and emission estimates, the air pollutant sources were classified into the following four categories:

1. Fuel combustion in stationary sources
2. Transportation
3. Solid-waste disposal
4. Industrial process losses

In the following sections, each of the categories is discussed, and a summary of the resulting emissions is presented.

Fuel Combustion in Stationary Sources

Although all of the three major fuels are consumed within the Study Area, coal is the most significant. In 1967, coal accounted for 256×10^{12} Btu's for 55 percent of the total energy input while natural gas accounted for 35 percent and fuel oil 10 percent. As shown in Table 3, approximately 9,100,000 tons of coal, 315 million gallons of fuel oil, and 162 billion cubic feet of natural gas were consumed in the Study Area.

The seven steam electric generating plants within the Study Area consumed 71 percent of the total coal utilized by all sources. All of the power plants are equipped with some form of air pollution control device. Six of the seven steam-electric utilities are fully equipped with electrostatic precipitators that range in efficiency from 90 to 99.5 percent. The remaining installation is equipped with settling chambers and mechanical collectors, with an overall efficiency of approximately 70 percent. Industry is the other prime user of coal consuming 18 percent of the total.

Table 3. ANNUAL FUEL CONSUMPTION IN POLITICAL SUBDIVISIONS OF
THE AIR POLLUTION STUDY AREA, 1967

Fuel	Jurisdiction	Consumption			
		Industry	Steam-electric plants	Residential	Totals
Coal, tons/year	City	507,600	248,900	350,200	91,800
	St. Louis County	191,000	2,415,000	126,500	37,500
	St. Charles County	640	1,230,000	13,900	N*
	Jefferson County	40,000	0	11,100	N*
	Madison County	509,100	2,365,000	122,300	19,900
	St. Clair County	397,500	203,000	163,500	24,300
	Monroe County	N*	0	7,900	N*
	Franklin County	N*		13,800	N*
	Totals	1,645,840	6,461,900	809,200	173,500
	City	6,280,000	844,000	28,990,000	3,480,000
Fuel oil, gal/ year	St. Louis County	23,040,000	0	51,300,000	1,670,000
	St. Charles County	60,000	0	7,340,000	20,000
	Jefferson County	380,000	0	8,500,000	3,000
	Madison County	131,630,000	924,000	16,700,000	260,000
	St. Clair County	7,234,000	730,000	17,200,000	770,000
	Monroe County	N*	0	1,460,000	N*
	Franklin County	N*		6,260,000	N*
	Totals	168,624,000	2,498,000	137,750,000	6,203,000
	City	18,280	477	23,577	9,360
Gas, million cubic feet/year	St. Louis County	10,595	2,351	22,000	1,172
	St. Charles County	N*	0	816	8
	Jefferson County	N*	0	1,050	N*
	Madison County	51,200	2,960	6,190	1,780
	St. Clair County	2,304	0	5,656	1,995
	Monroe County	N*	0	180	N*
	Franklin County	N*		226	N*
	Totals	82,379	5,788	59,695	14,315
	City				
	St. Louis County				
	St. Charles County				
	Jefferson County				
	Madison County				
	St. Clair County				
	Monroe County				
	Franklin County				
	Totals				

*N = Negligible.

Fuel oil is mostly consumed in industrial operations (54 percent) and for residential heating purposes (44 percent). Approximately 60 percent of this fuel oil is distillate with an average sulfur content of 0.28 percent. Most of the fuel oil consumed in the Study Area is burned in Madison County (47 percent). This is due to the large consumption of fuel oil by the three refineries in Madison County (over 109 million gallons).

Over 50 percent of the natural gas consumed in the Study Area is used in industrial operations while 37 percent is used for residential heating purposes. Only 3.5 percent of the natural gas is utilized in the steam-electric power plants.

Approximately 60 percent of the dwelling units in the Study Area use gas as the heating fuel. Coal and distillate fuel oil were both used in 20 percent of the dwelling units (Table 4).

The area variation in the use of a particular fuel can be examined in Table 4. Natural gas is used in approximately 64 percent of the dwelling units in the Missouri portion and 55 percent in the Illinois portion; coal is used in 30 percent on the Illinois side and 16 percent on the Missouri side; fuel oil is used in 24 percent on the Illinois side and 19 percent on the Missouri side. It should be noted that some houses in the Study Area use electricity or LP gas for heating. Since there are very few houses which use this type of heating (less than 4 percent) they were not considered in the total.

The commercial-institutional use of fuels is minor when compared to the other consumer categories. Similarly, the pollution load arising from these establishments is relatively small. This consumer category consumed less than 10 percent of any of the fuels used in the Study Area.

Table 4. SUMMARY OF DOMESTIC HEATING BY NUMBER OF
DRELLING UNITS IN THE STUDY AREA, 1967⁶

	Missouri Portion			Illinois Portion			Percent of total
	St. Louis City	St. Louis County	St. Charles County	Jefferson County	Madison County	St. Clair County	SNSA
All occupied units	328,972	218,534	12,389	16,692	78,793	86,199	741,579 100.0
Coal	71,884	19,346	2,300	1,965	21,191	28,986	145,672 19.6
Fuel Oil	39,680	52,270	8,082	10,009	19,305	20,304	149,650 20.2
Utility Gas	217,408	146,918	2,007	4,718	38,297	36,909	446,257 60.2

The sulfur and ash content of the fuels used in the Study Area are summarized in Table 5.^{7,8} The sulfur content of the coal is relatively high while that of the fuel oil is average.

Emissions from Fuel Combustion

Air pollutant emissions resulting from fuel combustion in stationary sources are listed in Table 6. The emissions are presented for industrial, steam-electric utility, residential, and miscellaneous sources.

Although coal accounts for only 55 percent of the total fuel energy in the Study Area, it is responsible for over 98 percent of the particulates, 95 percent of the sulfur oxides, 80 percent of the nitrogen oxides, 95 percent of the hydrocarbons, and 99 percent of the carbon monoxide emitted from stationary combustion sources in the Study Area. The use of coal in industrial operations is responsible for 35 percent of the particulates and 17 percent of the sulfur oxides while its utilization in steam-electric power plants accounts for 40 percent of the particulates and 68 percent of the sulfur oxides.

The emissions resulting from the combustion of fuel oil and natural gas are minor compared to that from coal combustion.

Data Sources

Fuel consumption data for the Study Area were obtained from the files of the various agencies, the 1963 St. Louis Emission Inventory, and from literature searches. These data were compiled by consumer categories and by major political subdivisions of the Study Area. It should be noted that while the total fuel oil consumed in the Study Area is accurate, its distribution by county may not be. Conflicting information was obtained on determining this distribution and that which has been presented is the only result which can be justified. The techniques used in assessing the fuel consumption for each of the user categories are briefly summarized below.

Table 5. CHEMICAL ANALYSIS OF FUELS
IN THE ST. LOUIS STUDY AREA, 1967

Fuel	Chemical Analysis of Fuels		
	Sulfur %	Ash %	Volatile %
Coal	3.0	9.1	35
Residual fuel oil	1.50	N*	--
Distillate fuel oil	.28	N*	--
Gas	.0008	N*	--

N* = negligible

Table 6. AIR POLLUTANT EMISSIONS FROM COMBUSTION OF FUELS IN
STATIONARY SOURCES IN THE ST. LOUIS AIR POLLUTION STUDY AREA, 1967
(tons/year)

Fuel	User Category	Particulates	Sulfur oxides	Nitrogen oxides	Hydrocarbons	Carbon monoxide
Coal	Industrial	43,620	93,800	20,690	1,034	3,104
	Steam electric	50,313	368,300	71,611	680	1,397
	Residential	20,970	46,123	3,296	4,120	20,603
	Other	4,300	9,889	446	557	2,784
	Totals	121,743	518,112	96,043	6,391	27,888
Fuel oil	Industrial	1,939	20,108	3,026	138	138
	Steam electric	46	291	156	4	4
	Residential	551	3,066	2,303	129	129
	Other	12	493	103	6	6
	Totals	2,548	23,958	5,588	277	277
Gas	Industrial	741	16	8,814	N*	16
	Steam electric	52	1	619	N*	1
	Residential	537	12	6,387	N*	12
	Other	129	3	1,531	N*	3
	Totals	1,459	32	17,351	N*	32
Grand Totals		123,210	542,102	118,982	6,668	28,197

N* = negligible

Industrial

The coal usage for the City of St. Louis was obtained from a questionnaire sent to 230 of the largest coal consumers by the St. Louis City and County Division of Air Pollution. A total of 198 of the 230 responded to the questionnaire. These users accounted for over 90 percent of the industrial coal use in the City of St. Louis. The coal usage for the remaining counties was obtained either by personal contact or by updating the 1963 survey.

Because of the lack of available information, the fuel oil totals for all counties except Madison and St. Clair were assumed to be the same as those used in 1963. In Madison and St. Clair counties more recent data were available from the State of Illinois.

The gas totals for each county were obtained from the utility companies which serve each area.

Steam Electric

The annual consumption of fuels by each of the seven public utility steam-electric generating plants was obtained by the local agencies through questionnaires and verified by information published by the National Coal Association.⁹

Residential

The coal consumption for the City of St. Louis was obtained from coal sales data. For the rest of the counties, the coal usage was assumed to be the same as in 1963. The total fuel oil and gas consumed by each county was determined by updating the 1963 numbers on the basis of population increases in each county.

Other

There are more than 12,000 commercial and institutional establishments in the Study Area. Included in this total are public and private institutions, schools, commercial concerns, and hospitals. Except for the City of St. Louis, where more

recent data were available, the same values were used as were used in 1963. This is only a rough approximation and should be interpreted as such. In any event, the fuel use data and the resulting pollutant emissions from this consumer category are minor when compared to the total emissions from fuel use in the Study Area.

Transportation

Four types of transportation sources of air pollution are considered in this survey - road vehicles, aircraft, railroad, and vessels. Road vehicles (automobiles, buses, and trucks) which are by far the most important community-wide transportation source of air pollution are further subdivided according to the type of fuel - gasoline or diesel.

Road Vehicles

The quantity of gasoline and diesel fuel consumed in a community is an index to the amounts of the various pollutants released to the air of the community from the operation of automobiles, buses, and trucks. The quantity of gasoline sold in a metropolitan area is approximately the same as the amount consumed in the area. For the purposes of this investigation, gasoline sales in the Study Area, less evaporation and other losses, are considered to equal the amount consumed.

On the basis of gasoline sales data, it is estimated that approximately 856 million gallons of gasoline (after evaporative losses) were consumed in the Study Area during 1967 (Table 7). Approximately 76 percent of this total was consumed in the City and County of St. Louis (Table 8).

The annual diesel fuel consumption in the Study Area is approximately 14 million gallons per year, of which buses consume 8 million gallons and trucks 6 million (Table 7).

These estimates of motor fuel consumption are based on growth factors which were applied to the 1963 Interstate Emission

Table 7. GASOLINE AND DIESEL FUEL CONSUMPTION
ROAD USE IN THE AIR POLLUTION STUDY
AREA, 1967 (10⁶ gallons/year)

<u>Fuel and use</u>	<u>Quantity</u>
Gasoline	
Road use	856.5
Evaporation	17.5
Diesel fuel	
Buses	8.1
Trucks	6.3

Table 8. GASOLINE AND DIESEL FUEL CONSUMPTION
IN STUDY AREA POLITICAL SUBDIVISIONS
(million gallons/year)

<u>Political Subdivisions</u>	<u>Gasoline</u>		<u>Diesel Consumption</u>
	<u>Consumption</u>	<u>Evaporation</u>	
City of St. Louis	351.9	7.2	10.7
St. Louis County	296.4	6.1	2.2
St. Charles County	22.5	0.5	0.1
Jefferson County	24.8	0.5	0.1
Madison County	75.7	1.5	0.6
St. Clair County	81.2	1.6	0.7
Monroe County	4.0	0.1	Negligible
Total	856.5	17.5	14.4

Inventory. Approximately 1.5 to 2.0 percent of the gasoline was lost through evaporation and this amounted to over 17 million gallons.

Aircraft, Railroads, and Vessels

In 1967 itinerant operations (flights that do not originate and terminate at St. Louis) totaled 320,485; local operations (flights that do originate and terminate at St. Louis) totaled 21,108. An "operation" as used here means a takeoff and landing. A summary of air traffic activity by category is given in Table 9.

Railroads consume about 27 million gallons of diesel fuel per year in the Study Area. Approximately 10,300 vessels, primarily diesel-powered tugs, pass through the area each year. An estimated 13,000 gallons of fuel oil are consumed per month per mile of river. These figures for railroads and vessels are from the 1963 Interstate Air Pollution Study.²

Emissions from Transportation Sources

The quantities of pollutants attributed to transportation sources is summarized in Table 10. More than 1.2 million tons of carbon monoxide, 276,000 tons of hydrocarbons, and over 56,000 tons of nitrogen oxides are emitted per year.

Road vehicles account for over 98 percent of the carbon monoxide, 89 percent of the nitrogen oxides, and 97 percent of the hydrocarbons emitted from transportation sources. The contribution of diesel fuel is almost insignificant in comparison with that of gasoline.

Solid-Waste Disposal

Approximately 1.5 million tons of combustible refuse were generated during 1967 in the Study Area. The bulk of this refuse (53 percent) is disposed of by sanitary landfills, and the remainder by municipal incineration and open burning (Table 11). A variation of disposal practices among the different political subdivisions within the Study Area is clearly evident and is

Table 9. AIR TRAFFIC ACTIVITY AT LAMBERT FIELD,
ST. LOUIS COUNTY, MISSOURI,
FOR CALENDAR YEAR 1967¹⁰

	<u>Itinerant operations</u>	<u>Local operations</u>
Air carrier	145,911	None
General Aviation	153,943	19,833
Military	<u>20,631</u>	<u>1,975</u>
Totals	320,485	21,808

Table 10. AIR POLLUTANT EMISSIONS FROM TRANSPORTATION SOURCES IN
THE ST. LOUIS AIR POLLUTION STUDY AREA, 1967 (tons/year)

	<u>Carbon monoxide</u>	<u>Hydro- carbons</u>	<u>Nitrogen oxides</u>	<u>Sulfur oxides</u>	<u>Particulates</u>
Road vehicles ^a	1,245,000	267,000	49,900	4,100	5,400
Gasoline					
Exhaust	1,245,000	169,300	48,300	3,900	4,700
Blowby	N*	55,300	N*	N*	N*
Evaporation (tank and carburetor)	-	40,800	-	-	-
Diesel					
Exhaust	425	1,200	1,600	200	700
Aircraft ^a	25,800	5,500	2,000	215	1,200
Jet	1,700	1,000	900	211	1,000
Piston	24,100	4,500	1,100	4	100
Railroad ^b	800	2,500	3,000	500	1,500
Vessels ^b	360	1,100	1,350	250	670
Totals	1,271,000	276,000	56,000	5,100	8,800

^a1967 data

^b1962 data

N* = Negligible

Table 11. REFUSE DISPOSAL IN STUDY AREA, 1967 (TONS/YEAR)

Political Subdivision	Combustible Refuse Generated	Incineration		Open Burning		Landfills	Transferred Out
		Municipal	On-Site	Dumps	On-Site		
St. Louis City, Missouri	430,000	218,000	43,000	---	89,000	---	+ 80,000
St. Louis County, Missouri	585,000	---	30,000	---	31,000	420,000	+ 104,000
Franklin County, Missouri	34,000	---	300	2,000	7,000	18,000	+ 6,700
Jefferson County, Missouri	59,000	---	4,000	20,000	13,000	86,000	- 64,000
St. Charles, Missouri	50,000	---	5,000	---	21,000	40,000	- 16,000
Madison County, Illinois	156,000	---	2,000	2,000	63,000	31,000	+ 58,000
St. Clair County, Illinois	173,000	---	4,000	10,000	65,000	187,000	- 93,000
Monroe County, Illinois	10,000	---	---	1,000	4,000	16,000	- 11,000
Totals for Entire Area	1,497,000	218,000	88,300	35,000	293,000	798,000	+ 64,700

therefore considered in making emission estimates. These totals were obtained by updating the 1963 survey on the basis of the population increase.

Emissions from Solid-Waste Disposal

A total of 2,100 tons of nitrogen oxides, 17,500 tons of carbon monoxide, and 5,000 tons of particulates are emitted from solid-waste disposal practices in the Study Area. The breakdown of emissions by type of disposal practice is presented in Table 12. The majority of the emissions is due to on-site open burning of refuse transferred from the City of St. Louis and St. Louis County to the counties on the Illinois side of the river.

Industrial Process Losses

The St. Louis metropolitan area is a heavily industrialized complex with a significant number of plants that generate air pollutant emissions from their processes. The major emission sources include 4 petroleum refineries, 2 cement manufacturing plants, 2 steel mills, 3 steel foundries, 10 grain handling and processing facilities, 4 chemical manufacture plants, 5 sulfuric acid manufacturing plants, and a host of other operations. These major point sources are identified in Figures 4A and 4B. Also presented in these figures are the major point sources based on fuel combustion. Where adequate information was available, emission estimates were made and are included in this survey. As is the case in any emission inventory, the lack of emission factors for some of the industrial processes did not allow a complete estimation of process emissions.

Emissions from Industrial Process Losses

Air pollutants from industrial process losses account for 48,000 tons of particulates, 118,000 tons of sulfur oxides, 4,000 tons of nitrogen oxides, 43,000 tons of hydrocarbons, and 327,000 tons of carbon monoxide in the Study Area annually. The sources of these emissions are presented in Table 13 by jurisdiction.

Table 12. AIR POLLUTANT EMISSIONS FROM SOLID WASTE DISPOSAL
IN ST. LOUIS STUDY AREA, 1967 (TONS/YEAR)

	<u>Sulfur Oxides</u>	<u>Nitrogen Oxides</u>	<u>Carbon Monoxide</u>	<u>Hydrocarbons</u>	<u>Particulates</u>
Incineration	306	361	2,052	68	2,294
Municipal	218	218	109	33	1,853
On-Site	88	143	1,943	35	441
Open Burning	328	1,802	15,509	819	2,624
Dumps	35	192	3,060	87	280
On-Site	293	1,610	12,449	732	2,344
Total	634	2,163	17,561	887	4,918

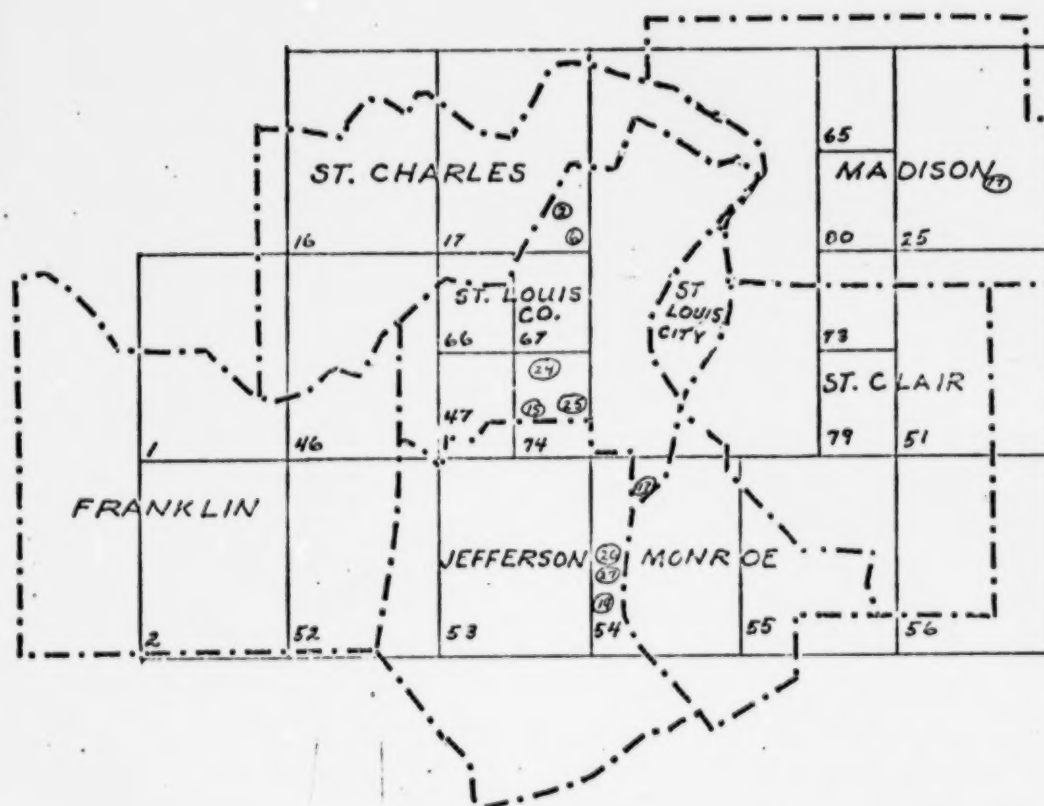


Figure 4A. Location of Major Point Sources in Study Area.

Key to Point Sources in Figure 4A and 4B.

- | | |
|--------------------------------------|--|
| 1. Sulfuric Acid | 15. Auto Manufacturing |
| 2. Rock, Gravel, and Sand Processing | 16. Meat Processing |
| 3. Petroleum Refineries | 17. Power Plant |
| 4. Chemical Plant | 18. Fertilizer Plant |
| 5. Cement Manufacturing | 19. Glass Manufacturing |
| 6. Ceramic and Clay Processes | 20. Asphalt Roofing Manufacturing |
| 7. Starch Manufacturing Plant | 21. Dairy |
| 8. Steel Mills | 22. Brewery |
| 9. Steel Foundry | 23. Rubber Plant |
| 10. Feed and Grain Mills | 24. Paint Industry |
| 11. Soap Manufacturing | 25. Asphaltic Concrete Batching Operations |
| 12. Railroad Car Manufacturing | 26. Nitric Acid |
| 13. Incinerator | 27. Lead Smelting |
| 14. Commercial Building | 28. Miscellaneous Manufacturing |

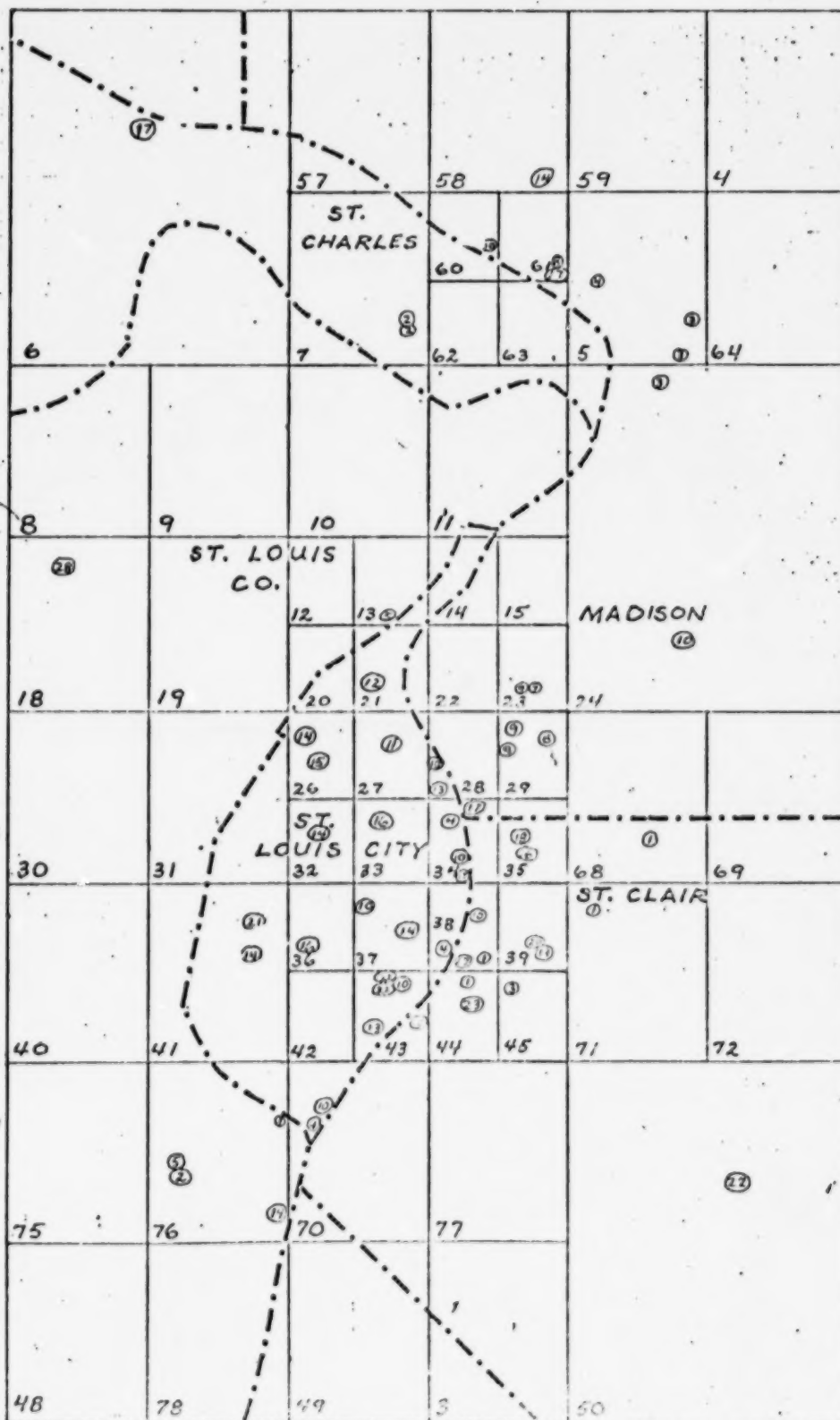


Table 13. SUMMARY OF INDUSTRIAL PROCESS EMISSIONS IN
THE AIR POLLUTION STUDY AREA, 1967 (tons/year)

Pollutant and sources	Missouri				Illinois		
	St. Louis City	St. Louis County	St. Charles County	Jefferson County	St. Clair County	Madison County	Area total
Particulates	0	77	0	0	156	0	233
Sulfuric acid manufacturing	18	N	0	0	2	18	38
Coffee processing	4,218	0	0	0	3,254	2,031	9,503
Grain industry	0	0	0	0	0	12,120	12,120
Steel mills	28	94	0	0	7	69	198
Asphaltic concrete batching	215	N	0	0	0	331	546
Steel foundries	265	0	0	0	116	12	393
Gray iron foundries	32	3	3	0	4	1	43
Nonferrous foundries	9	0	0	0	0	64	73
Coke plants	0	3,140	0	0	0	0	3,140
Cement plants	0	57	0	0	166	0	223
Superphosphate manufacturing	0	0	0	8,000	0	0	8,000
Ammonium nitrate manufacturing	0	0	7,124	0	312	0	7,436
Rock processing	0	0	50	0	2,435	3,384	6,063
Other sources	138	6					
Totals	4,973	3,377	7,177	8,000	6,452	18,030	48,009
Sulfur Oxides							
Sulfuric acid manufacturing	0	8,663	0	0	14,418	0	23,081
Lead Smelting	0	0	0	84,800	0	0	84,800
Other sources	NA	NA	NA	1,150	3,250	5,500	9,900
TOTALS	NA	8,663	NA	85,950	17,668	5,500	117,781

Table 13. page 2

Nitrogen oxides									
Nitric acid manufacturing									
Cement plants	0	0	0	2,475	0	0	2,475	0	2,475
Other sources	0	1,220	0	0	0	0	0	0	1,220
	5	NA	NA	NA	300	NA	NA	NA	300
Totals	5	1,220	NA	2,475	300	NA	NA	NA	3,995

Hydrocarbons									
Refineries	0	0	0	0	3,927	28,000	31,927		
Other sources	9,447	NA	NA	NA	1,500	NA	NA		
Totals	9,447	N*	N*	N*	5,427	28,000	42,874		

Carbon monoxide									
Refineries	0	0	0	0	32,600	295,000	327,600		
Other sources	N*	N*	N*	N*	N*	N*	N*		
Totals	N*	N*	N*	N*	32,600	295,000	327,600		

N* = Negligible

NA = Information not available or not reported

The major sources of process particulates in the Study Area are the steel mills (20 percent), grain handling and processing operations (25 percent), rock crushing (15 percent), and ammonium nitrate manufacturing (17 percent).

Sulfuric acid manufacturing plants are responsible for approximately 70 percent of the sulfur oxides emitted from process loss sources. These emissions mostly originate from St. Clair County.

Refineries located in Madison County and in St. Clair County account for approximately 75 percent of the hydrocarbons and 100 percent of the carbon monoxide emitted from process loss sources in the Study Area.⁹ The catalytic cracking units are responsible for most of the carbon monoxide; and tank farms, vacuum jets and catalytic cracking units for the hydrocarbon losses.

EMISSIONS BY GRIDS

For the purpose of modeling the air pollutant emissions in the Study Area, the resulting emissions are apportioned on the grid coordinate system. As was pointed out in the discussion of the grid coordinate system, two different grid systems were utilized in defining the emissions. Sulfur oxides, particulates and nitrogen oxides are apportioned on one grid system (Figure 1A and 1B) while hydrocarbons and carbon monoxide on another (Figure 3). Transportation is the biggest source of hydrocarbons and carbon monoxide in the Study Area. Since traffic flow and vehicular-mile data were not available for the smaller grid system a new grid system was used to define the hydrocarbon and carbon monoxide emissions.

The emissions of each pollutant is divided into two source subgroups - point sources and area sources. The 72 major point sources are identified by type of industry, grid number, and total emissions on an average day in Table 14. A summary of sulfur oxide, particulate, and nitrogen oxide emissions from

area sources is presented in Table 15, and emissions of carbon monoxide and hydrocarbons are presented in Table 16.

Table 14. SUMMARY OF SULFUR OXIDES, PARTICULATE, AND NITROGEN OXIDES EMISSIONS FROM POINT SOURCES.
(TONS/AVERAGE DAY)

Type of Industry	Grid No.	SO _x Emissions	Part. Emissions	NO _x Emissions
Power Plants				
1	61	248.8	95.3	43.64
2	34	116.8	14.91	21.81
3	34	38.9	4.98	6.84
4	38	31.94	4.05	5.66
5	6	192.1	1.97	33.70
6	25	3.59	4.58	.63
7	54	377.2	12.04	67.42
Rock, Gravel, and Sand Processing				
1	17	0	1.20	0
2	7	0	19.18	0
3	7	0	8.22	0
4	76	0	13.7	0

Table 14. Page 2

Type of Industry	Grid No.	SO _x Emissions	Part. Emissions	NO _x Emissions
Petroleum Refineries				
1	5	9.84	1.09	6.53
2	5	60.76	5.51	27.38
3	24	1.46	.15	1.82
4	45	19.87	.32	2.41
Cement Manufacturing				
1	13	0	2.79	1.08
2	76	0	5.80	2.26
Steel Mills				
1	61	1.63	2.04	1.43
2	29	6.02	.56	4.91
Steel Foundries				
1	23	5.14	7.98	1.59
2	29	.92	1.01	.34
3	29	6.19	.59	2.20
Asphalt Roofing				
1	39	6.95	8.70	1.23

Table 14. Page 3

Type of Industry	Grid No.	SO _x Emissions	Part. Emissions	NO _x Emissions
Asphaltic Concrete Batching Operations	74	0	1.95	0
1				
Breweries				
1	43	1.58	2.01	2.28
2	43	17.9	2.29	3.14
3	50	3.17	4.0	.56
Sulfuric Acid Manufacturing				
1	68	12.0	1.90	0
2	71	17.98	9.27	1.34
3	38	11.0	.17	0
4	44	50.77	19.77	5.28
5	76	44.0	4.09	96.23
Nitric Acid and Ammonium Nitrate Prod.				
1	54	0	21.9	6.76
Paint Industry				
1	74	0	2.4	0

Table 14. Page 4

Type of Industry	Grid No.	SO _x Emissions	Part. Emissions	NO _x Emissions
Miscellaneous Manufacturing				
1	18	3.70	.71	.64
Rubber Plant				
1	-44	2.12	4.26	.37
Dairy				
1	41	1.35	1.73	.23
Chemical Plants				
1	5	15.57	7.06	1.68
2	34	26.74	5.12	4.69
3	38	2.63	2.36	.46
4	70	7.82	5.99	1.37
Ceramic and Clay Processes				
1	17	0	3.04	0

Table 14: Page 5

Type of Industry	Grid No.	SO _x Emissions	Part. Emissions	NO _x Emissions
Starch Manufacturing Plant	23	18.79	10.80	3.08

Feed and Grain Mills

1	24	0	2.98	0
2	28	0	2.28	0
3	34	0	1.49	0
4	34	0	2.04	0
5	37	0	2.48	0
6	38	0	2.48	0
7	43	0	4.96	0
8	43	0	1.49	0
9	60	0	3.48	0
10	70	0	3.78	0

Soap Manufacturing

1	27	2.38	.76	.42
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Railroad Cars

1	21	.98	1.22	.28
---	----	-----	------	-----

Table 14. Page 6

Type of Industry	Grid No.	SO _x Emissions	Part. Emissions	NO _x Emissions
Auto Manufacturing				
1	26	5.66	4.70	.99
2	74	4.74	6.05	.82
Meat Processing				
1	33	2.30	2.05	.40
2	35	11.56	9.05	1.59
3	36	6.08	5.44	1.07
Fertilizer Plants				
1	35	0	8.0	0
Glass Manufacturing				
1	39	0	3.5	0
2	54	2.93	.374	.50
Commercial Establishments				
1	26	1.68	.21	.29
2	32	3.29	2.94	.58
3	37	2.22	2.84	.39
4	41	3.15	4.02	.55

Table 14. Page 7

Type of Industry	Crid No.	SO _x Emissions	Part. Emissions	NO _x Emissions
5	76	2.50	3.19	.42
6	58	1.42	.27	.24
Incineration				
1	28	.30	2.55	.30
2	43	.30	2.55	.30
Lead Smelting				
1	54	232.33	5.98	.82

Table 15. SUMMARY OF SULFUR OXIDES, PARTICULATE, AND
NITROGEN OXIDES EMISSIONS FROM AREA SOURCES BY GRID LOCATION
FOR ST. LOUIS STUDY AREA
(TONS/AVERAGE DAY)

Grid No.	Sulfur Oxides Emissions	Particulate Emissions	Nitrogen Oxides Emissions
1	.01	.04	.03
2	.01	.04	.03
3	.27	.13	.03
4	1.28	.50	.23
5	2.80	1.41	.61
6	.21	.23	.09
7	.18	.24	.04
8	.48	.21	.18
9	.77	.23	.24
10	.20	.13	.05
11	.21	.10	.09
12	.23	.13	.15
13	.14	.09	.12
14	.07	.12	.09
15	.01	.07	.05
16	.44	.28	.08
17	.88	.47	.27
18	2.29	1.38	.74
19	1.12	.52	.61
20	1.43	.73	.51
21	.77	.46	.60
22	.67	.33	.11
23	1.78	1.02	.51
24	.85	.48	.22
25	1.07	.49	.16
26	3.74	3.38	2.51
27	1.17	.84	1.17

Table 15. Page 2

Grid No.	Sulfur Oxides Emissions	Particulate Emissions	Nitrogen Oxides Emissions.
28	1.21	.97	.94
29	2.03	2.01	.40
30	2.82	2.11	1.16
31	19.28	7.68	2.68
32	11.61	4.83	1.67
33	6.95	3.15	1.89
34	4.35	2.26	2.30
35	.86	2.35	.59
36	8.66	3.84	2.16
37	6.02	2.66	.84
38	2.76	1.20	1.67
39	2.26	.96	.25
40	2.89	1.97	.42
41	5.31	4.90	2.99
42	2.83	1.16	.97
43	5.15	3.05	2.04
44	1.21	.67	.75
45	.23	.15	.10
46	1.90	1.85	.70
47	.58	.34	.15
48	.48	.18	.13
49	.14	.11	.01
50	2.20	.89	1.19
51	1.43	.65	.22
52	1.41	.69	.22
53	1.16	.58	.33
54	1.00	.39	1.20
55	.43	.24	.04
56	.70	.24	.14
57	.05	.15	.01
58	.41	.24	.12
59	1.34	.69	.25

Table 15. Page 3

Grid No.	Sulfur Oxides Emissions	Particulate Emissions	Nitrogen Oxides Emissions
60	.68	.80	.10
61	.88	.28	.62
62	.13	.07	.03
63	.09	.22	.02
64	1.66	.80	.42
65	.32	.17	.13
66	.42	.22	.07
67	.84	.57	.23
68	5.62	2.49	.79
69	1.57	2.90	.28
70	3.12	7.58	.73
71	8.12	3.43	.97
72	.49	.26	.11
73	2.24	.92	.30
74	.62	.26	.20
75	.44	.12	.16
76	.43	.37	.27
77	.33	.68	.06
78	.35	.16	.06
79	5.21	2.09	.68
80	1.36	.53	.23

Table 16. SUMMARY OF CARBON MONOXIDE AND
HYDROCARBON EMISSIONS BY GRID LOCATION
FOR ST. LOUIS STUDY AREA
(TONS/AVERAGE DAY)

Area Sources	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Grid No.																			
CO Emissions	18.9	19.3	65.6	170.4	18.8	20.3	109.9	2438.9	373.7	36.6	3.5	117.2	100.2	26.5	9.7	1.9	9.4	9.8	1.5
Hydrocarbon Emissions	3.9	3.9	24.2	34.6	3.9	4.1	23.6	518.9	71.0	7.8	.57	25.7	22.4	5.3	1.9	.30	1.9	1.8	.24

Point Sources	Refinery	Refinery	Refinery	Refinery	Refinery	Power Plant	Power Plant	Sulfuric Acid Plant
Category	Refinery	Refinery	Refinery	Refinery	Refinery	Power Plant	Power Plant	Acid Plant
Grid No.	4	4	4	4	45	3	13	13
CO Emissions	206.1	522.1	82.4	89.3	10.7	1.1	1.7	3.1
Hydrocarbon Emissions	19.8	50.0	7.6	10.7		.44	.66	2.7

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